EXPERIMENTAL INVESTIGATION IN MEDICAL MARKETS AND INSTITUTIONAL SOURCES OF PRICE INFLATION

C.A. JOHNSTON,* Interdisciplinary Center for Economic Science,
George Mason University, Fairfax, VA

ABSTRACT

We constructed a three-party market in which experts, non-experts, and insurers negotiated with each other for services, insurance coverage, and cash in such a way that we could observe prices over successive rounds of negotiations and determine whether or not they showed inflationary tendencies. We used agent-based software to execute the experiment. We found that three-party transactions among insurers, experts, and nonexperts showed inflationary tendencies, but two-party transactions between experts and non-experts did not. The findings suggested that institutional sources of price inflation can exist on the basis of the order of negotiations when there is an intermediary between consumer and supplier. The findings are consistent with a theoretical argument by Frech and Ginsburg (1975) showing that medical insurance reimbursement systems with certain price-control characteristics caused chronic price inflation

FRECH AND GINSBURG

Frech and Ginsburg **(1975)** analyzed a model in which health insurance induces chronic inflation. In the model, medical providers agreed with insurers to furnish unlimited services at rates set according to a survey of “usual and customary” fees within a geographic region. The policy paid a level of reimbursement equivalent to some percentile in the distribution, usually between the 75th and 90th percentile. Frech and Ginsburg then showed that by fixing the fees in the short run, the insurer set off a chain of events that caused prices paid by consumers to rise until the market was saturated. The speed of the increases depended on the percentile of the distribution chosen and the frequency of revision of the prevailing rates.[1]

“When fee schedules are set by a prevailing rate mechanism, certain plausible assumptions give rise to a chronic inflation in the fee schedule, with the rate depending on how often the schedule is adjusted and the percentile in the fee distribution chosen as the prevailing rate. This inflation only ends when consumers of medical care reach saturation,” Frech and Ginsburg concluded.

---

* *Corresponding author address:* **Carl A. Johnston**, Ph.D. student, Interdisciplinary Center for Economic Science, George Mason University, 4400 University Drive, MSN 1B2, Fairfax, VA 22030; dcjohnst@earthlink.net.

1 It is frequently argued that medical price inflation has not historically been driven by price increases for existing procedures. “The main reason healthcare is continuing to absorb a larger share of the economy is innovation: that the range of things that medicine can do keeps increasing” (McClellan, heart study, **Cutler et al. 2001)**. Procedures not covered by insurance include Lasik, dentistry, and cosmetic procedures.

An alternative possibility is that in an industry characterized by technological innovation, prices for existing procedures should *decline* in real terms. Therefore, the stable appearance of medical prices might mask a tendency for prices to be much higher than they would be in a more transparent market.

Frech and Ginsburg also showed that fixed-fee payments (conceptually similar to diagnostic related group payments currently used by Medicare) were less inflationary than reasonable and customary fees described above but were still inflationary. Since the fixed payments were also based on a percentile of a distribution of prevailing rates, the mechanics of fixed payment work much like reasonable and customary fees.

Frech-Ginsburg Model

The Frech-Ginsburg model assumed that health care providers charged fees for their services subject to conventional assumptions about utility of services and income to consumers and provider costs. The model assumed that some health care consumers had a health insurance policy that paid an indemnity *i* when the insured consumer suffered an illness that initially cost P_{t0} to treat. The cost of the treatment could be described as a function of *i* and some premium function of services consumed, *p*:

$$P_{t0} = i + p(x),$$

where *p* is the premium that could be charged in addition to the indemnity depending on the level of service provided *x*. The model assumed that $P_{t0} > 0, p(x) > 0$. Therefore, **when (ok?)** $P_{tj} > P_{t0}$ and it is assumed that the level of *i* is set according to an average of previous period prices, the insurer sets the price for period P_{tj} at the previously prevailing market price P_{t0}. The price for the next market period then becomes

$$P_{tj} = P_{t0} + p(x).$$

The authors claimed the price of the service would continue to rise until the market became saturated. (Frech and Ginsburg 1975).

We can examine Frech's and Ginsburg's basic claim by simulating an environment in which negotiations proceed in a fixed order. The order of negotiation then forms the framework for computer simulations and laboratory experiments to study the emergence of inflation.

Negotiation Order

In our simulation, as in Figure 1, negotiations between agent types over commodities occur in a fixed sequence. First, insurer and non-expert exchange cash (Cash 1) for coverage (Coverage 1). Next, expert and non-expert exchange coverage (Coverage 2) for services. Finally, expert and insurer exchange coverage (Coverage 3) for cash (Cash 2).

Valuations

Each of the non-experts was assigned an initial level of cash. Experts had an initial stock of services to sell, and insurers had an inventory of coverage. Each agent type also had preferences over each commodity. Non-experts preferred to own services, which they could only obtain after first buying coverage. Experts wanted cash. Insurers wanted coverage.

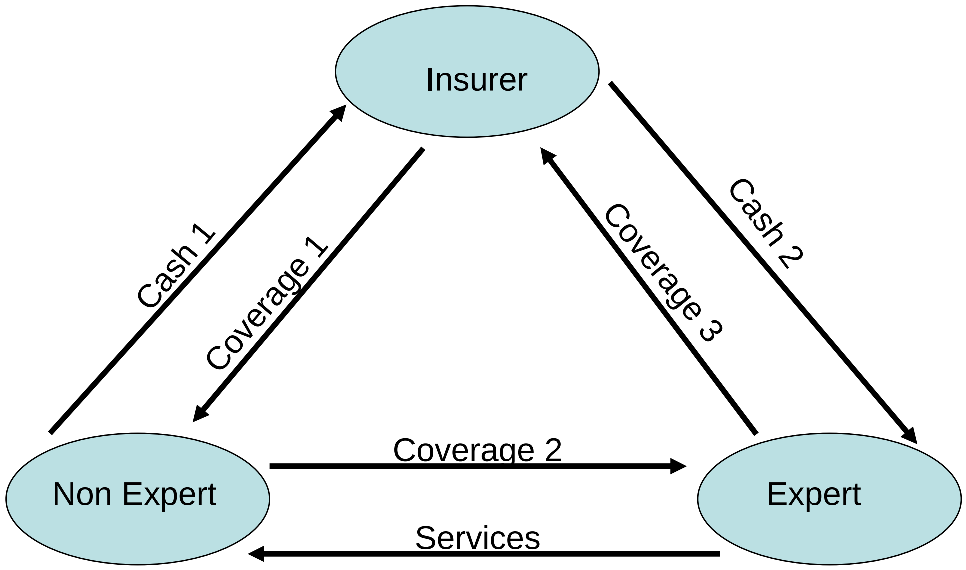


FIGURE 1 Three-party trading system with insurer

In the first set of transactions, insurers negotiated with non-experts for premiums (thereby pre-setting a constraint on any later transactions involving insurance coverage). Later transactions with insurance must be less than the value of the insurance coverage premium (Cash 1) and also less than the amount of coverage traded for the premium (Coverage 1). Each leg of the transaction was bound by the previous set of negotiations. Therefore, Cash 2 was constrained by Cash 1. Coverage 3 was constrained by Coverage 2, which, in turn, was constrained by Coverage 1. The amount of services provided to the non-expert could not exceed reimbursements to the expert (Cash 2). In each leg, both parties were assumed to trade in a fair manner, meaning that the value of coverage is at least as valuable as the cash tendered in return. Likewise, services and coverage traded between expert and non-expert have comparable value. The full set of constraints is laid out in Figure 1. The outcome of the completed negotiation round constrains the next round of negotiations.

Bargaining Rules and Price Formation

Exchange was accomplished by bilateral barter between agents at mutually-agreed-upon prices by using a posted offer mechanism. Each set of negotiations was subject to its own set of constraints. All constraints, in turn, were dependent on the outcome of previous negotiations, as outlined in Figure 2.

The constraints were not violated when the amount of services corresponded exactly to the amount of coverage purchased at an exchange rate of one unit of coverage for each unit of cash. However, because the exchange rate between coverage and services is only constrained and not fixed by the initial negotiation (between insurer and non-expert), we can see that the expert can profit by undersupplying services for a given amount of coverage. Likewise, insurers can profit by buying back coverage from the expert for less than they sold it to the non-expert in

$$\sum_{i=1}^{I}\sum_{n=1}^{N} Cash1 \geq \sum_{e=1}^{E}\sum_{i=1}^{I} Cash2 \geq \sum_{n=1}^{N}\sum_{e=1}^{E} Services$$

$$\sum_{i=1}^{I}\sum_{n=1}^{N} Coverage1 \geq \sum_{e=1}^{E}\sum_{n=1}^{N} Coverage2 \geq \sum_{i=1}^{I}\sum_{e=1}^{E} Coverage3$$

$$\sum_{i=1}^{I}\sum_{n=1}^{N} Cash1 = \sum_{i=1}^{I}\sum_{n=1}^{N} Coverage1$$

$$\sum_{i=1}^{I}\sum_{e=1}^{E} Coverage3 \geq \sum_{i=1}^{I}\sum_{e=1}^{E} Cash2$$

$$\sum_{n=1}^{N}\sum_{e=1}^{E} Coverage2 \geq \sum_{n=1}^{N}\sum_{e=1}^{E} Services$$

FIGURE 2 Constraints on three-party trading system

exchange for cash. If each agent takes advantage of the profit opportunities afforded it by the order of negotiation, then the value of coverage will steadily devalue relative to cash, resulting in inflated prices for services.

The continuous devaluation of the value of coverage throughout the order of the negotiations accounted for the price inflation that Frech and Ginsburg postulate. This also gave some extra justification for Frech's and Ginsburg's claim that the rate of inflation depended in part on how often fee schedules are adjusted (how many attempts are made in each cycle) within the insurance system.

Three-party Experiment

In this paper, we take a well-known agent-based computer simulation model, the zero-intelligence trader, and modify it to accommodate transactions between three types of agents. Gode and Sunder demonstrated that zero-intelligence trader could simulate transactions between different types of agents with heterogeneous preferences over different objects. Gode and Sunder (1993) showed that this procedure used in the context of a multi-agent program produced price and efficiency results that were comparable to those generated by a laboratory double auction, as explained in Smith (1962).

Agent-based Simulation

Although there is an established body of literature for multi-agent "zero-intelligence" bargaining, published accounts typically discuss environments with only two types or one type of agent (buyers, sellers, or buyer-sellers). It is simple to alter this existing program environment designed for two types of agents and to add a third agent to it. The three types of agents in the redesigned ZITrader are insurers, experts, and non-experts. Experts and non-experts can be thought of as generic representations of doctors and patients. The three types of agents then use the ZI Trader activation methodology to trade three quantities: cash, services, and coverage.

Agents are assigned an initial endowment of cash, coverage, and services. (Non-experts have cash; experts have services; insurers have coverage). We also give each agent preferences over each good, such that non-experts desire services; experts desire cash, and insurers want coverage. The preference for coverage is always relatively low relative to each agent's desire for the other type of commodity.[2]

Preferences Algorithm

We use an algorithm for representing preferences borrowed from sugar and spice trader in order to endogenously set marginal preferences of agents over commodities on the basis of their holdings. Specifically, Axtell-Epstein showed how agents can be programmed with Cobb-Douglas preferences over objects. We extend this model slightly by adding a third term to the Cobb-Douglas multipliers. The program then randomly activates agents and assigns them to buyer or seller roles depending on which agent has the higher marginal rate of substitution (MRS) for the given object with respect to the numeraire. Equation set 0.3 shows how to determine an agent's MRS for one good w_2 with respect to another good w_1. After determining respective values of MRS, the program determines a transaction price by calculating the geometric mean of the respective MRS levels, as explained by Albin and Foley (1990).

$$MRS = \frac{dw_2}{dw_1} = \frac{\dfrac{\delta W(w_1, w_2, w_3)}{\delta w_1}}{\dfrac{\delta W(w_1, w_2, w_3)}{\delta w_2}} = \frac{\dfrac{m1}{m2} w_1^{(m1-m2)/m2} w_2^{m2/m1}}{\dfrac{m2}{m1} w_1^{(m1/m2)} w_2^{(m2-m1)/m1}} = \frac{m_1 w_2}{m_2 w_1}$$

Simulations were attempted by using a Cobb-Douglass function with preferences as follows:

Experts:

$$U_E = X^{0.1} C^{0.1} S^{0.8}$$

Non-experts:

$$U_N = X^{0.1} C^{0.8} S^{0.1}$$

Insurers:

$$U_I = X^{0.8} C^{0.1} S^{0.1}$$

where *X* stands for units of insurance coverage, *C* is cash, and *S* is services. *E* stands for expert, *N* for non-expert, and *I* for insurer.

---

2 In each case, we also assign a very small amount of nonpreferred quantities to each agent, and we also give each agent a small amount of value for nonpreferred commodities. In this way, we avoid the problem of Cobb-Douglas functions when they begin a round with zero inventory of a traded commodity that has zero preference, thus forcing a division by zero error.

ORDER OF NEGOTIATIONS

The main program's code can be altered to contain subroutines that control how each agent would be randomly activated and made to trade with each other agent type. By sequencing the order in which the subroutines are called, one can simulate the desired order of negotiations. By repeatedly calling the routines in order, one can then simulate several rounds of negotiations.

The program calls subroutines in a specific order. First, non-experts and insurers trade cash for coverage. Then non-experts and experts trade coverage for services. Finally, insurers and experts trade coverage for cash. High-MRS buyers are matched with low-MRS sellers, and the two agents trade as described above. Trades are recorded and statistically analyzed by a standard data agent routine, also modified from the ZITrader program.

The number of attempts made to trade is a parameter in the program. In the simulations described here, the program makes 50 attempts to find qualifying buyers and sellers. The number of attempts is important to the exercise. Making a large number of attempts would satiate non-expert demand for coverage and thereby end the market process in the first round. Frech-Ginsburg, however, implies that rounds occur at a frequency such that market demand cannot be satiated in one round. Therefore, the program discussed here limits the number of potential transactions to 50, ensuring that demand is not satiated in the first round. The program executes the cycle of negotiations four times. By trial and error, we discovered this is the number of rounds required to exhaust the bulk of gains from trade.

Purpose of the Simulation

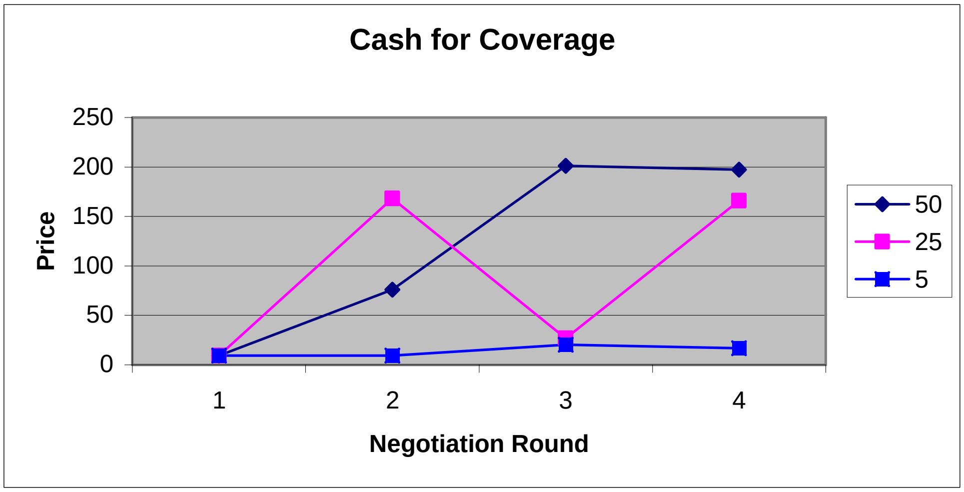
The purpose is to prove the feasibility of a test of the Frech-Ginsburg theory of inflation through simple transactions in a prescribed order of negotiations.

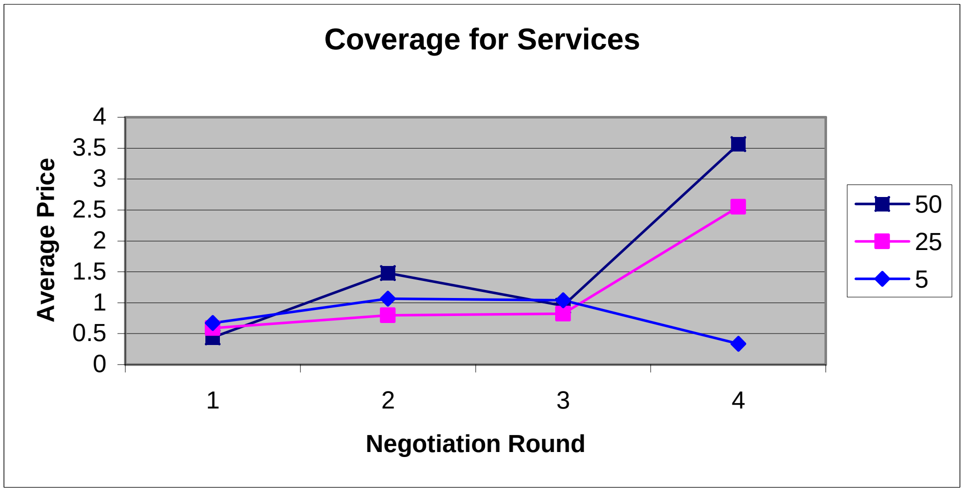
Simulation Results

The agents bargained with each other as explained above. Agents were randomly activated, and trade attempts were made. The software generated 50 of each type of agent, and each agent type was assigned the same number (5) of some initial stock of tradable commodity as well as tiny amounts of the other two tradable commodities. For example, non-experts had an initial stock of 5 units of cash; however, they also had initial stocks of 0.1 unit of coverage and 0.1 unit of services in order to avoid dividing by zero when conducting initial trades. The experts and non-experts were similarly furnished with initial stocks of services and coverage, respectively, as well as de minimis amounts of the other two commodities. For the reasons discussed earlier, trade attempts were limited to 50.

What We Learned from the Experiment

The simulation established that the trading scheme does produce many of the kinds of imbalances that one might expect it to show given our discussion earlier. Prices for services inflate at each stage and during each period. Reimbursements to experts for services show a





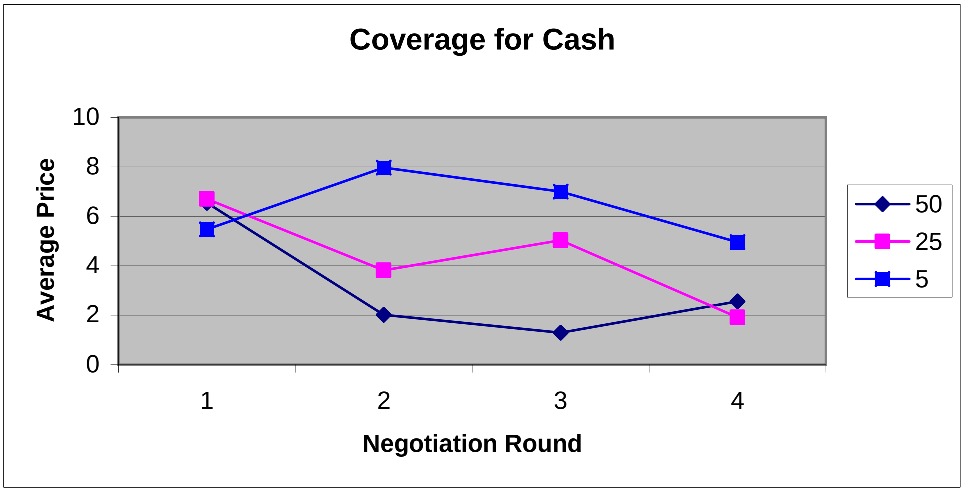


FIGURE 3 Average prices and variances from agent-based simulation

decreasing trend over time, even as prices of insurance coverage go up. A progressive devaluation of the "currency" of insurance coverage seems evident. Inflation in the prior period acts as a foundation for price gains in succeeding rounds of negotiations. **call out fig. 3 here?**

Surprises

This version of the software produces extraordinarily large variances in prices and steep gains in prices from one period to the next (and steep reimbursement declines for the expert in the coverage-for-cash leg). The large variances are related to the initial trades in which there are several agents with zero holdings of the commodity being traded.

COUNTERFACTUAL EXPERIMENT

A counterfactual experiment, in which two parties trade and are found to create no inflation, would be the best way to verify the claim that the three-party institutional negotiation order causes the price inflation. If inflation occurs in the three-party structure but not in the two-party structure that is otherwise identical to the three-party experiment, then we can justify the claim that it was the procedure of negotiation and nothing else that caused the observed price increases.

The counterfactual experiment is easy to carry out. In order to turn the simulation into a two-party experiment, we simply place two slash marks in front of the lines that call for cash-for-coverage and coverage-for-cash routines, and we allow only the coverage-for-services routine to execute four times. The full findings are summarized in Table 2 and presented at length in Exhibit 3 at the end of this paper. **need callouts for exhibits 1 and 2 too**

TABLE 2 Counterfactual experiment results

	Coverage for Services			
Parameter	Round 1	Round 2	Round 3	Round 4
Average	0.63180726	0.482374001	0.399636988	0.43643578
S.D.	0.100377281	0.170497875	0.195787679	0

The prices in the counterfactual experiment do not violate the notion that they all come from the same distribution and therefore no discernible inflation trend is visible. This is a sharp contrast to the previous experiments, in which inflationary gains in prices were clearly evident and significant.

WHY HUMAN EXPERIMENTS ARE NEEDED

This paper has demonstrated two different theoretical models and two sets of computer simulations that complement each other in terms of enforcing our understanding of how inflation generated by institutional sources would work and what such price inflation would look like and under what circumstances it might occur. The findings suggest that not only is such an effect possible, but it appears to be robust.

On the other hand, introduction of humans into the mechanism might change the dynamics significantly. For example, if non-experts withhold demand or if experts sell their services at less than their value, it might have a dampening effect on prices and possibly even create an (inefficient) equilibrium. Therefore, a replication of the simulation described in this paper but using humans instead of agents might yield valuable information about how human-operated, noncomputational organizations handle the dynamics of three-party negotiations.

CONCLUDING OBSERVATIONS

The health care sector draws in more and more resources each year. Medicare cost escalation is thought to be a significant threat to the financial stability of the United States. Rising health care costs are among the most frequently cited causes of job destruction. Yet despite accelerating costs, we have little to show for the expense, since health indicators have not improved much in 30+ years. The proportion of persons without health insurance, infant death rates, and male life expectancy have not improved as much as one might have hoped, given the vast resources being expended on the problem. Yet the most recent scholarship on the causes of inflation in health care dismiss the notion that inflationary pricing contributes to the escalation of health care costs. For example, McClellan et al. (2001) studied the cost of heart attack treatment. and concluded that "spending increases are mostly driven by changes in the quantity and type of services provided, not changes in the price of a given service."

These findings have given rise to a discussion about how to curb the demand for greater intensity of treatment for diseases, such as heart attacks. One academic/policymaker has gone so far as to suggest outright that limitations on the amount of profit that developers of innovative medical products can make on new inventions constitute the best way to reign in runaway costs (presentation at George Mason University in February 2005 by Tomas J. Philipson, The University of Chicago, former Assistant Commissioner of Medicare).

It is not usually the case that technical innovations present these kinds of problems. Usually, the technical advance produces deflation. For example, computers are much more capable and much more numerous in 2005 than they were in 1980. Yet nobody thinks of computing costs as being out of control. This is because in fields characterized by innovation, it is common to see prices decline, sometimes sharply. If we were still paying the same price for a 1985 microprocessor in 2005, or a little less, we might consider it a bad trade.

Therefore, the fact that prices of old medical technologies remain stable or decline a bit does not necessarily mean that prices are behaving in a noninflationary way. The work in this report is intended to suggest that institutional sources of price inflation can exist on the basis of the order of negotiations, particularly when there is an intermediary between consumer and supplier. The simulations and theoretical work show that experimental methods could be used to explore behavioral, institutional, and economic system design that would substantially benefit our understanding of these kinds of situations.

One can also imagine many extensions of these experiments. For example, could we design a market for insurance claims that might moderate the apparent inflationary tendency inherent to U.S.-style health insurance plans?

ACKNOWLEDGMENTS

I gratefully acknowledge the advice and criticism of Robert Axtell, Dan Houser, Stephen Rassenti, and David Porter, as well as financial support from the Mercatus Center and the James M. Buchanan Center for Political Economy at George Mason University.

REFERENCES

Albin, P., and D.K. Foley, 1990, "Decentralized, Dispersed Exchange without an Auctioneer: A Simulation Study," *Journal of Economic Behavior and Organization 18*(1), pp. 27–51.

Cutler, D.M., M. McClellan, J.P. Newhouse, and D. Remler, 2001, "Pricing Heart Attack Treatments," in D.M. Cutler and E.R. Berndt, *Medical Care Output and Productivity*. Chicago, IL: University of Chicago Press.

Epstein, J.M., and R. Axtell, 1996, *Growing Artificial Societies: Social Science from the Bottom Up*. Washington, DC: MIT Press.

Frech, H.E., and P.B. Ginsburg, 1975, "Imposed Health Insurance in Monopolistic Markets: A Theoretical Analysis," *Economic Inquiry 75*(1), pp. 55–70.

Gode, D.K., and S. Sunder, 1993, "Allocative Efficiency of Markets with Zero-intelligence Traders: Market as a Partial Substitute for Individual Rationality," *Journal of Political Economy 101*(1), pp. 119–137.

Smith, V.L., 1962, "An Experimental Study of Comparative Market Behavior," *Journal of Political Economy 70*, pp. 111–137.

2 Universal Mark-up Language (UML) description of three-way trader

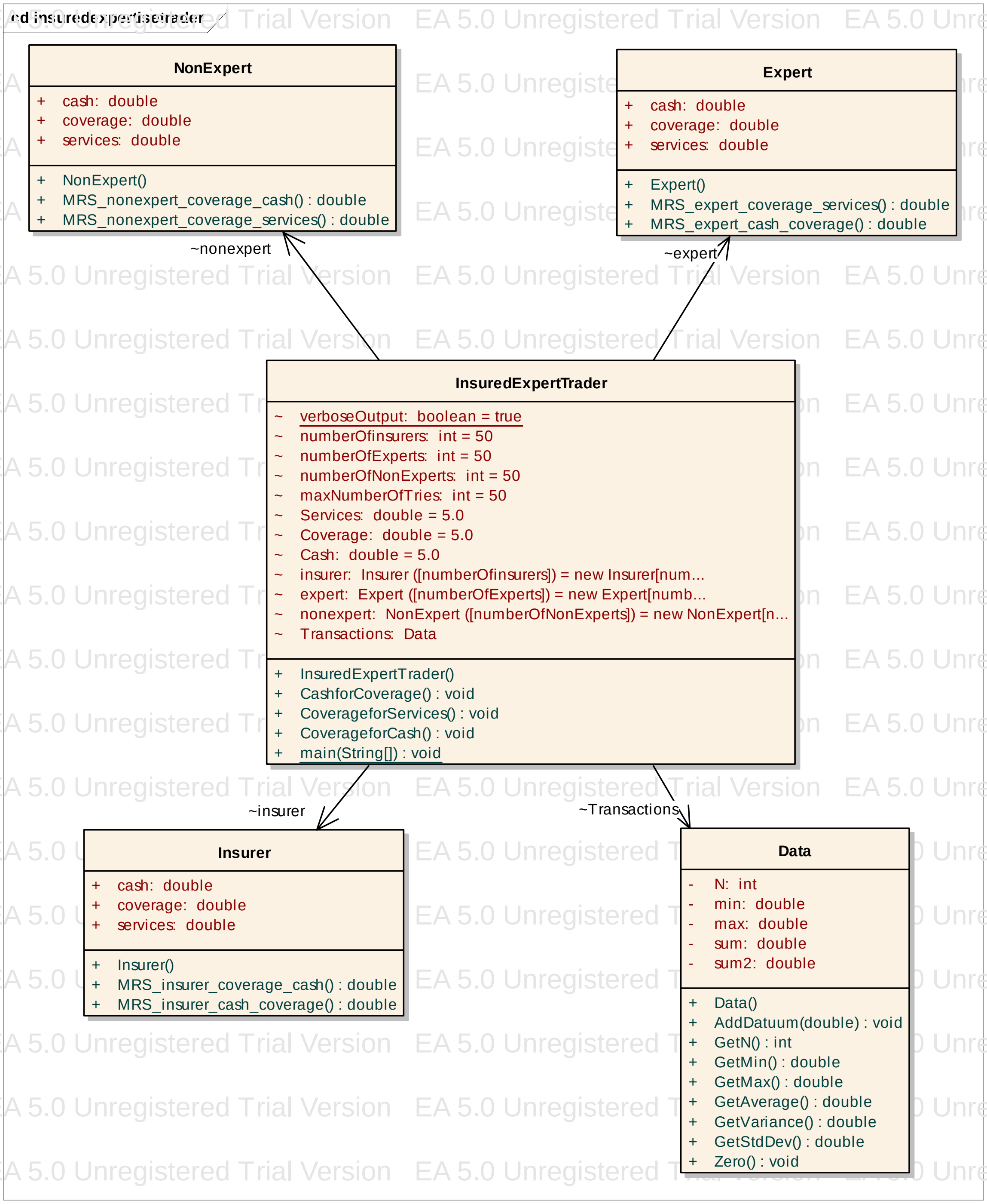


EXHIBIT 1 Multi-agent simulation of three-party experiments

Original Distribution of Coverage, Cash, Services

NonExpert / 0/ 250/ 0

Insurer / 250/ 0/ 0

Expert / 0/ 0/ 250

Distribution after trading Coverage for Cash

NonExpert / 25/ 125/ 0

Insurer / 225/ 125/ 0

Expert / 0/ 0/ 250

Update Distribution after Trading Coverage for Services

NonExpert / 9/ 125/ 37

Insurer / 225/ 125/ 0

Expert / 1/ 0/ 213

Distribution after trading Coverage for Cash

NonExpert / 9/ 125/ 37

Insurer / 225/ 96/ 0

Expert / 1/ 29/ 213

Totals / 235/ 317/ 250

Distribution after trading Coverage for Cash

NonExpert / 21/ 65/ 37

Insurer / 213/ 156/ 0

Expert / 1/ 29/ 213

Update Distribution after Trading Coverage for Services

NonExpert / 8/ 65/ 69

Insurer / 213/ 156/ 0

Expert / 9/ 29/ 181

Distribution after trading Coverage for Cash

NonExpert / 8/ 65/ 69

Insurer / 219/ 135/ 0

Expert / 6/ 48/ 181

Totals / 233/ 335/ 250

Distribution after trading Coverage for Cash

NonExpert / 16/ 25/ 69

Insurer / 211/ 175/ 0

Expert / 6/ 48/ 181

Update Distribution after Trading Coverage for Services

NonExpert / 8/ 25/ 95

Insurer / 211/ 175/ 0

Expert / 13/ 48/ 155

Distribution after trading Coverage for Cash

NonExpert / 8/ 25/ 95

Insurer / 220/ 161/ 0

Expert / 5/ 58/ 155

Totals / 233/ 347/ 250

Distribution after trading Coverage for Cash

NonExpert / 12/ 5/ 95

Insurer / 216/ 181/ 0

Expert / 5/ 58/ 155

Update Distribution after Trading Coverage for Services

NonExpert / 5/ 5/ 110

Insurer / 216/ 181/ 0

Expert / 6/ 58/ 140

Distribution after trading Coverage for Cash

NonExpert / 5/ 5/ 110

Insurer / 221/ 170/ 0

Expert / 4/ 69/ 140

Totals / 230/ 345/ 250

EXHIBIT 2 Price evolution in three-party simulation

	Coverage for Cash			Services for Coverage			Cash for Coverage		
	1st Period	2nd Period	3rd Period	1st Period	2nd Period	3rd Period	1st Period	2nd Period	3rd Period
Avg	9.438798	118.7625	278.5622	0.442944	1.058568	2.176739	4.970369	3.630569	1.738485
Var	0	10203.68	18964.91	0.086874	0.894776	2.377667	18.5324	28.83809	1.548212

EXHIBIT 3 This Entire exhibit needs to be removed

Original Distribution of Coverage, Cash,/ Services

NonExpert / 0/ 250/ 0

Insurer / 250/ 0/ 0

Expert / 0/ 0/ 250

Update Distribution after Trading Coverage for Services

NonExpert / 0/ 250/ 31

Insurer / 250/ 0/ 0

Expert / 0/ 0/ 219

/n Stats after trading Coverage for Services: 31 transactions took place at 0.6318072598177861 average price; 0.10037728051751019 standard deviation. /n)

Update Distribution after Trading Coverage for Services

NonExpert / 0/ 250/ 44

Insurer / 250/ 0/ 0

Expert / 0/ 0/ 206

/n Stats after trading Coverage for Services: 13 transactions took place at 0.4823740008931712 average price; 0.17049787522922566 standard deviation. /n)

Update Distribution after Trading Coverage for Services

NonExpert / 0/ 250/ 49

Insurer / 250/ 0/ 0

Expert / 0/ 0/ 201

/n Stats after trading Coverage for Services: 5 transactions took place at 0.399636988045828 average price; 0.19578767907593872 standard deviation. /n)

Update Distribution after Trading Coverage for Services

NonExpert / 0/ 250/ 50

Insurer / 250/ 0/ 0

Expert / 0/ 0/ 200

/n Stats after trading Coverage for Services: 1 transactions took place at 0.4364357804719847 average price; 0.0 standard deviation. /n)